REMARKS

Office Action Recap

The office action objected to claims 1-17 because of bad grammar. The office action objected to claims 2-17 because of indefiniteness of the term "at least". The office action objected to claims 2, 3, 7, 8, 9, 11, 14, and 16 because of inconsistent use of the term "sensor". The office action objected to claim 17 because the antecedent for "said light-to-frequency converter" was incorrectly identified.

The office action rejected claim 17 under 35 U.S.C. 112 for unclear and inadequate description. The office action rejected claims 1, 5, 7, 8, 12, 14, and 16 under 35 U.S.C. 102(e) as being anticipated by Izumizaki et al. The office action rejected claims 2, 3, and 13 under 35 U.S.C. 103(a) as being obvious in view of Izumizaki et al and further in view of Merchant et al. The office action rejected claims 4 and 6 under 35 U.S.C 103(a) as being obvious in view of Izumizaki et al and further in view of Budnik. The office action rejected claim 15 under 35 U.S.C. 103(a) as being obvious in view of Izumizaki et al and further in view of Rakitsch. The office action rejected claims 9-11 under 35 U.S.C. 103(a) as being obvious in view of Izumizaki et al and further in view of Hameister et al.

The office action provisionally rejected claims 2, 3, and 13 for obviousness-type double patenting, with respect to copending Application No. 10/095,166.

The office action noted the following prior art as pertinent to the disclosure, though not relied upon in the office action.

US 5,237,181

US 5,471,282

US 6,229,972

US 6,144,024

Summary of Amendments

In the amended specification, the term "sensor" is reserved for the overall assembly for sensing transmitted or reflected light from a sample area opposite the "sensor". The "sensor" may include mechanical, optical, and electronic parts—such as light shields, lenses, filters, photodiodes, amplifiers, and light-to-frequency (L-to-F) converters. The light-sensitive component of the "sensor" is denoted by the term "light detector".

The references to a copending application are changed from an abandoned application to a Continuation-in-part application currently pending.

In the new claims, the bad grammar is corrected. The new claims state specific ranges for the number of sensors and the number of probes, and avoid the indefiniteness of "at least". As in the amended specification, the new claims reserve the term "sensor" for the overall assembly for sensing transmitted or reflected light from a sample area opposite the "sensor". The light-sensitive component of the sensor is denoted by the term "light detector".

The unclear description in the cancelled claim 17 has been corrected in new claim 37, emphasizing how the probe length determines the measurement spot position, in the cross-track direction.

The new claims are for multi-channel densitometers having from 1 to 8 probes. With two or more probes, the probes are independently locatable with respect to each other. The probes may also be independently locatable with respect to the controller. In the single probe configuration claimed, the probe has from 3 to 8 sensors distributed over the length. (Izumizaki Figures 4 and 5 may be considered as implicitly disclosing a single probe with two channels.) In the multi-probe configurations claimed, each probe has from 1 to 8 sensors, to measure density at 1 to 8 distinct positions.

Reference Shows Where 8 Probes or 8 Sensors Are Useful

In US 5,988,067 to Ishida et al, Figure 2 and column 3 lines 10-15 describe an 8-color printing press. This printer is a generic representation of commercial color printers configured with as many as 8 color stations, such as the 5-color Mitsubishi Double Diamond press, the 2-, 4-, and 5-color Hamada presses, and the 8-color Heidelberg Sunday 2000. In an 8-color electrophotographic printer, 8 densitometer probes may be useful, one at each color station. Alternatively, a single probe with 8 sensors may be useful to monitor test patches of 8 colors after they are all transferred and collected on a receiver in separate tracks.

Probe Length Sets Measurement Track

For a probe as described in the present application on page 15, lines 11-15 with reference to Figure 2, and page 19, lines 11-20 with reference to Figure 6, the probe length determines the reach from the web edge to the measurement track. Figure 2 shows 3 probes of the same length, for measurements in the same track. When test patches of different colors are printed in different tracks, probes of different lengths may be used to reach the patches in the respective tracks. As shown in Figure 2, each such probe has a sensor at one end. The probe is mounted with the other end opposite the web edge, from which a cable connects to the controller. Applicant submits that new claim 37 is clear and enabled in view of this part of the specification.

Izumizaki Dedicates Separate Controller for Each Color

The Izumizaki embodiments represented by US 6,505,010 Figures 1 and 2 have, for each color station, a single density detector connected to a single controller. The overall 4-color machine thus has 4 single-channel densitometers, rather than a multi-channel densitometer. This configuration lacks the advantages of low cost and simplicity of a multi-channel densitometer.

Izumizaki Density Sensors in Fixed Positions

The Izumizaki embodiments represented by US 6,505,010 Figures 4 or 5 have 2-channel densitometers. The two density detectors are shown in fixed positions near the web

edges, with electrical connections to a single controller shown schematically. Izumizaki does not show or explain the mechanical supporting structure for the density detectors. The density detectors could be mounted directly to the machine frame. Alternatively, both density detectors could be mounted on a single probe extending straight across the web, and secured to the frame of the machine. Izumizaki provides no suggestion or motivation to make the two density detectors independently locatable, i.e., on separate probes. Nor is there any suggestion that more than two density detectors across the web width could be useful.

The 2-channel configuration of Figure 4 or 5 is replicated for each color station, with no suggestion that a single controller could service density detectors for more than one color station. Applicant submits that the densitometers disclosed by Izumizaki have at most two channels, and further, that Izumizaki does not disclose independently locatable probes.

No Double Patenting

The new claims do not include any claims comparable to the dependent claims provisionally rejected, where the light detector is a light-to-frequency (L-to-F) converter. The objection for the incorrectly identified antecedent for the L-to-F converter is also obviated.

Conclusion

The amended specification and claims have corrected the informalities objected to in the office action. An additional prior art reference has been submitted showing multi-color printers with up to 8 colors. This reference is discussed to show where up to 8 probes and up to 8 sensors on a single probe would be useful.

The importance of probe length has been explained, and the unclear description in the cancelled claim 17 has been corrected in new claim 37.

The Izumizaki disclosure has been shown not to include multiple independently locatable probes, and not to include densitometers with more than two channels. The claims of the present application have been amended so as not to claim a single probe configuration with only two sensors, as that configuration may be considered implicitly disclosed by Izumizaki.

The new claims eliminate the issue of provisional rejection for double patenting, as raised in the office action with respect to cancelled claims 2, 3, and 13. The objection for the improper antecedent is also obviated.

Applicant submits that the application is now in proper form for allowance, which action applicant respectfully requests. The Examiner is invited to contact the undersigned via telephone if such communication would expedite allowance of this application.

Conditional Request for Assistance

If the Examiner agrees that there is patentable subject matter in the application, but finds the present claims unacceptable, applicant respectfully requests that the Examiner write acceptable claims pursuant to MPEP 707.07(j).

Very respectfully,

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May 19, 2003 Allen J Rushing

Allen J. Rushing, Applicant

VERSION WITH MARKING TO SHOW CHANGES MADE

<u>In the Specification:</u>

On page 1, replace the section entitled "CROSS REFERENCE TO RELATED APPLICATIONS" as follows:

CROSS REFERENCE TO RELATED APPLICATIONS

Reference is made to co-pending U.S. Patent Application, filed on [April 3, 2000] <u>March 11, 2002</u> in my name as follows:

Ser. No. [09/543094] <u>10/095,166</u>, entitled DIGITAL DENSITOMETER USING LIGHT-TO-FREQUENCY CONVERTER[, PERIOD COUNTER, AND LOOKUP TABLE].

On page 6, replace the paragraph beginning on line 18 as follows:

Advancing component technologies are reducing the aforementioned cost barriers, making densitometers cost-effective in an increasing range of applications. On-board densitometers have gradually penetrated the printer market, down even to some moderately priced printers. Less costly and more reliable LEDs are now often used instead of incandescent lamps as densitometer light emitters. Photodiode [sensors] <u>light detectors</u> are smaller and less costly than the photomultiplier tubes used in some older densitometers. Application of digital electronics to densitometers eliminates the need for the costly analog logarithmic amplifier used in traditional analog designs. For example, U.S. Patent Application Serial No. [09/543094] <u>10/095,166</u> of Rushing discloses an all-digital approach based on a light-to-frequency <u>(L-to-F)</u> converter electrically interfaced to a microcontroller and utilizing a look-up table (LUT). Despite these cost-reducing advances, densitometer cost is still an issue in printer design, particularly when multiple densitometers are considered for moderately priced products. The cost of bench-top densitometry, particularly multi-channel densitometry, also remains an issue in amateur photo labs, student laboratories, and other cost-sensitive areas.

Beginning on page 7 line 4, replace the entire section entitled "SUMMARY OF THE INVENTION" as follows:

SUMMARY OF THE INVENTION

One object of the present invention is to reduce densitometer cost for density measurement at multiple positions, for both bench-top and on-board applications. A single controller circuit, preferably with a digital microcontroller, provides electrical power, control signals, and sensor signal processing for multiple channels with preferably digital [sensors] light detectors in one or more probes. With the preferable digital [sensors] light detectors, the costly analog logarithmic amplifiers of traditional analog densitometers are eliminated. The controller circuit may be located on a probe along with the sensors for one or more channels, or may be on a separate connected circuit board. In either case, the components of the controller circuit are not replicated for each channel, further cutting costs.

Typically, the densitometer measurement channels are located on a single machine, or at a single bench-top work area. However, probes in multiple machines may also be connected to a single controller circuit, especially if the machines are close to each other and operated together.

Each densitometer probe contains at least one light sensor, in which the light-detecting component is preferably a small [light-to-frequency] L-to-F converter integrated circuit. The corresponding light emitters, preferably LEDs, may also be included on the probe. The LEDs, if not a part of the probe, are separately mounted in positions that align with the sensors on the probe when the probe is in its operating position. Separate LED mounting is sometimes preferable in a transmission mode of operation, where the LED and [photodetector] light detector are on opposite sides of the sample.

For mounting the probes, slide rails facilitate easy installation and removal, and establish a well-defined position relative to the sample to be measured. Alternatively, a mounting block at the connector end of the probe facilitates attachment to a support structure for cantilever mounting. The connector at the end of the probe is disconnected for easy probe removal, such as for cleaning. Should a probe become damaged or inoperative, only that one probe need be replaced—not the other probes or the separate controller circuit board.

Another object of the invention is a reduced space requirement at the measurement locations. By limiting the probe components and function to the minimum required to output digital signals responsive to light impinging on the [sensors] light detectors, the probes can be made small. In particular, the probe width, in the process direction, can be minimized. [A light-to-frequency] An L-to-F converter in integrated circuit form, along with a controller circuit serving multiple channels, minimizes the total component count. With a separate controller circuit board, the probe electronic components for each channel may consist of only [a small integrated circuit sensor] the L-to-F converter, a decoupling capacitor, and the LED emitter with a series resistor (unless the LED is separately mounted). In some applications the probe may include additional sensor components such as light shields, lenses, and color filters.

With less space required by the densitometer probes, more space is available for various work stations, or for enabling overall reduction in machine size. Alternatively, the small probe may permit a needed density measurement where it could not be done with a bulkier complete densitometer. The small probe size, along with the electrical connector and mounting provisions, facilitate probe removal and replacement. Relocation of a probe to another measurement position is also easier, if that should be necessary.

Yet another object of the invention is to compute multi-channel, as well as single-channel, density functions in the densitometer controller circuit, where the density signals

from all the channels are collected. Evaluations of uniformity[,] or transfer efficiency, for example, require multi-channel density measurements. Only the required calculated results, measurement summaries, statistics, or exceptions are sent to the host computer or display device. This unburdens the host computer from such computations, allowing it to better and more timely attend to higher-level machine control functions. If the connection to the host is wireless, outputting only summary data may also be advantageous in terms of reduced time duration of the transmission and/or reduced bandwidth.

Still another object of the invention is superior noise immunity, obtained by utilizing an all-digital approach. The issue of electrical noise immunity is heightened in multi-channel and multi-probe configurations, owing to the multiplicity of interconnections in the generally noisy environments inside printers or other machines. Electrophotographic printers, for example, contain noisy devices such as motors and corona chargers, making noise immunity essential for accurate multi-channel densitometry. In some prior art densitometers, analog signals are switched, which can introduce additional transient noise or steady error. In the present invention, the preferred [light-to-frequency] L-to-F converter integrated circuit has a digital (logic "high" or logic "low") frequency output. The digital output has inherently better noise immunity than the analog input and output signals associated with the photodiodes, linear amplifiers, logarithmic amplifiers, and analog-to-digital converters of traditional densitometer designs. There is no switching of sensitive analog signals.

To obtain these objects, the multi-channel densitometer in the preferred embodiments utilizes an all-digital design and a single controller circuit to control and process signals to and from multiple measurement channels. The microcontroller of the controller circuit controls and processes signals individually for the channels, and also computes multi-channel functions requiring readings from two or more channels. The [light-to-frequency] L-to-F converter integrated [circuit sensors] circuits, one for each channel, provide digital frequency outputs. Control signals are also exclusively digital. This gives

the multi-channel densitometer the superior noise immunity inherent in digital signals. The [light-to-frequency] <u>L-to-F</u> converter integrated circuits also contribute to the minimal component count, small probe size, and economical cost.

The invention and its various advantages will become more apparent to those skilled in the art from the ensuing detailed description of the preferred embodiments, reference being made to the accompanying drawings.

On page 11, replace the paragraph beginning on line 3 as follows:

With reference to the portion of a wide-format machine shown in FIG. 1, a single probe 21a provides three channels of density measurements as web 18 advances in the direction shown by arrow "A". Each channel provides density measurement in either the reflection mode or the transmission mode. Probe 21a extends across web 18, with three [light-to-frequency converter] sensors 22a, 22b, and 22c facing web 18 near the front edge, center, and rear edge. For reflection density measurement of the top side of web 18, light emitters, preferably LEDs, are mounted on circuit board 23, positioned and aligned to illuminate spots on web 18 opposite the respective sensors 22a, 22b, and 22c, as detailed in FIG. 7.

On page 12, replace the paragraph beginning on line 4 as follows:

Frequency outputs from sensors 22a, 22b, and 22c are all connected to controller circuit 30. Controller circuit 30 provides electrical power to all three channels, and receives a digital frequency output from each channel, with frequency proportional to the light impinging on the respective sensors. The light impinging on <u>the L-to-F converter of</u> each sensor is a portion of the light from an LED that has been transmitted through or reflected from web 18. Thus the frequency outputs are characteristic of the transmission or reflection optical density of the respective spots on web 18 transmitting or reflecting light to the sensors. Controller circuit 30 may also output digital control signals to the

channels, such as programmable codes for sensitivity and frequency divide-by ratio, if the [light-to-frequency] L-to-F converters are programmable in real time.

On page 12, replace the paragraph beginning on line 22 as follows:

Controller circuit 30 measures either the period or the frequency of the frequency outputs from the three channels of probe 21a. Preferably the period is measured in terms of clock counts to yield a period count. The period count is utilized in entering a look-up table to obtain the scaled optical density value corresponding to web 18 transmittance or reflectance, using a circuit and a method such as disclosed in U.S. Patent Application No. [09/543,094] 10/095,166. Controller circuit 30 also contains digital processing circuitry, preferably within a microcontroller, which computes, stores, compares, and otherwise processes the signals from all of the connected channels, according to the application.

On page 17, replace the **one** paragraph beginning on line 23 with **two** paragraphs as follows:

FIG. 6 shows detail of a preferred probe for transmission densitometry. Light from LED 70c shines through transmissive web 18. The beam pattern emitted from LED 70c is typically broad and divergent, as indicated by the arrows. A portion of the emitted light is transmitted through web 18 and impinges on [light-to-frequency] the L-to-F converter of sensor 22d. In general, discrete components may be used for [light-to-frequency] L-to-F converter circuits. For small size and best noise immunity, [sensor 22d] the L-to-F converter is preferably an integrated circuit, such as Texas Advanced Optoelectronic Solutions, Inc. model TSL230 or TSL235.

The 8-pin TSL230 has pins for real time digital control of sensitivity and frequency divide-by ratio by the controller circuit. This programmability facilitates measurement of a wide density range with good density resolution, and a fast density update rate. The non-programmable 3-pin TSL235 is a smaller and lower-cost circuit well suited to

applications with less demanding requirements for density range, density resolution, or measurement update rate. The TSL235 can be a good choice for reflection densitometry, where density usually saturates well below 2.0 density units. Transmission densitometry often requires a larger range, depending on the application. Decoupling capacitor 71, standard for integrated circuits, stabilizes [sensor 22d] the L-to-F converter at its supply voltage pins.

On page 19, replace the paragraph beginning on line 1 as follows:

The sensitive area of [sensor models] the TSL230 and TSL235 is only about 1 mm^2. With such small [sensors] light detectors, an LED with a wide uniform beam pattern is preferred, making accurate LED-to-sensor alignment less critical, and reducing alignment sensitivity. Perfect alignment is not essential, because the base reading saved previously is subtracted. The base reading is determined during calibration and depends on a number of factors, including spacing and alignment. To avoid density measurement error, spacing and alignment (or moderate misalignment) should remain fixed after calibration. A recalibration would typically be done at regular intervals or whenever spacing or alignment may have been disturbed.

On page 20, replace the paragraph beginning on line 9 as follows:

FIG. 7 shows detail of a preferred probe for reflection densitometry. To illustrate that a probe may have multiple densitometer channels, this probe has two similar channels, for measurement in two cross-track positions. Each channel has its own LED and sensor. For one channel, light from LED 70e obliquely illuminates spot 32e of web 18. A portion of the light is diffusely reflected from spot 32e, and impinges on the [light-to-frequency] L-to-F converter of sensor 22e. Light shield 79e blocks the direct path for light from LED 70e to sensor 22e, and other extraneous light. Thus sensor 22e receives only light reflected from spot 32e, illuminated by LED 70e. For smallest size and best

noise immunity, sensor 22e [is] preferably uses an integrated circuit L-to-F converter, as in the transmission type probe of FIG. 6. Decoupling capacitors (not shown in FIG. 7) are provided for each integrated circuit [sensor], as in FIG. 6. The mounting options for the reflection probe are also similar to those discussed for the transmission type probe of FIG. 6. A second reflection density channel in FIG. 7 uses LED 70f, which illuminates spot 32f. Reflected light from spot 32f impinges on the L-to-F converter of sensor 22f, shielded by light shield 79f.

On page 22, replace the paragraph beginning on line 11 as follows:

For the TSL230 [light-to-frequency] L-to-F converter [sensor], the sensitivity and divide-by ratio each have 2-bit codes, and each has two dedicated pins on the integrated circuit. Microcontroller 84 measures the period of the frequency outputs from the sensors of all channels one at a time in a rapid cycle. Microcontroller 84 outputs the same programming code in common to all the sensors. FIG. 8 shows a 4-wire programming output to the sensors, to program both the sensitivity and the divide-by ratio of the TSL230. If the density range to be covered is not too large, it may be adequate to program only one of the sensitivity or divide-by ratio, thus reducing by two the number of conductors in the cables to the probes. It may also be adequate to program only one of the two bits for the sensitivity or divide-by ratio. In such cases, the non-programmed bits are hard-wired on the probe.

In the Claims:

Claims numbered 1 through 17 have been cancelled.

New claims numbered 18 through 37 have been added.